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Waste materials co-processing in cement industry: Ecological efficiency of waste reuse

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ABSTRACT

Cement is the main component of concrete, which is, in turn, the second most consumed material on earth, in addition, the cement industry is one of the most intensive energy consumptions. The modern plants often have nominal production capacity exceeding one million tons per year. To produce one ton of cement, you need the equivalent of 60–130 kg of fuel and 110 kWh of electricity. Due to the large consumption of energy, which represents over 30% of the total production cost for the cement industry, the reduction in spending on energy inputs is a major motivation for technological advances in the production process of cement. To reduce the costs of fossil fuel consumption (non-renewable source), the technique of co-processing has been employed for introducing alternative fuels as part of the manufacturing process. This technique provides a lower cost of production, introducing fuel waste from different industrial activities, besides contributing to the reduction of environmental liabilities; they generate waste when discarded in inappropriate places. It is evident that the cement industry sector is highly intensive in energy consumption, and should be considered in studies on energy planning, especially with the changes in its energy matrix, which has occurred continuously since the oil crisis in 70 years, still that this change is very heterogeneous when one considers each manufactures cement. The ecological analysis is done through comparison between ecological efficiency, pollution indicator and values for CO_2 equivalent from cement industry rate, before and after adoption of waste reuse.

Contents

1. Introduction

The Portland cement production begins with the raw material extraction, where the limestone is the main component. Once milled, the limestone is mixed with other inputs, such as clay, iron,

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silicon, and aluminium. This mixture is named as raw flour. This mixture is sent to kilns, where it is heated to temperatures between 1,200 and 1,500 °C, leading to a partial material melting and formation of clinker granules. This material is cooled, mixed with small amount of other ingredients, such as gypsum and slag from blast furnace, and milled, giving rise to Portland cement [1,2]. Fig. 1 shows the schematic representation of cement production.

The cement industry is considered energy-intensive, because its energy needs to achieve high temperatures. Traditionally, it used fossil fuels such as coal, fuel oil, and petroleum coke. The co-processing of industrial waste is an attempt to reduce the use of such fuels. In this process, waste is added to raw materials by replacing, in part, fuels or virgin raw material itself [3].

Co-processing is the use of waste as raw material (without changing the final quality of product), or as a source of energy, or both to replace natural mineral resources (material recycling) and fossil fuels such as coal, petroleum and gas (energy recovery) in industrial processes, mainly in energy intensive industries (EII) such as cement, lime, steel, glass, and power generation. Waste materials used for co-processing are referred to as alternative fuels and raw materials (AFR) [4].

Before this waste is put into clinker (the main raw material for cement) furnaces, there are pre-treatments to ensure that waste characteristics remain constant and it will not cause adverse effects to the cement produced or to the environment.

Besides the challenge of constantly increasing its production capacity, another issue of the cement industry is the high demand for energy, for example, in 2009, the sector accounted 1.7% of final energy consumption in Brazil [5].

As a way to reduce this dependence, the main strategies are being adopted to increase energy efficiency and fuel replacing. Over time, companies have been investing in process changes and new technologies, achieving significant results in increasing its energy efficiency. Over the last six years, despite the increase in cement production, the sector managed to reduce the energy intensity of cement from 0.083 toe/t (2003) to 0.071 toe/t (2009), representing gains of 17% in terms of energy efficiency [5,6].

In addition to investments in energy efficiency, companies have also found to modify its energy sources, especially motivated by the question of cost, the cement industry was able to transfer its dependence on fuel oil, which accounted for 91% of energy in 1970, to petroleum coke and was responsible for 66% of energy in 2005 [7].

Considering the situation of cement industry in constant expansion and the need to use cheaper fuels, co-processing has emerged as a great business opportunity for the sector. This alternative is even five to ten times cheaper than conventional forms of incineration. The price charged for incineration varies between US$ 1,000 and US$ 3,000 a tonne, depending on the type of waste. The disposal in landfills can cost US$ 150 a tonne. The burning in cement kilns ranges from US$ 100 to US$ 700 [8].

A typical plant for Portland cement production had been analysed for this study, located in Balsa Nova, PR, with an installed production capacity of 1.5 million tonnes of cement per year and employing the co-processing since 1993.

The cement industry waste co-processing has been studied by several authors in order to decrease environmental impacts, such as [9,19].

A novel design of an integrated process for cement production incorporating municipal solid waste (MSW) separation and combustion had been developed by [9], where 85–90% volume reduction was achieved and the MSW ash was used as a feedstock for the production of the cement clinker.

Co-processing of hazardous wastes in cement kilns have for decades been thought to cause increased emissions of PCDD/PCDFs—a perception that had been evaluated in [10], where more

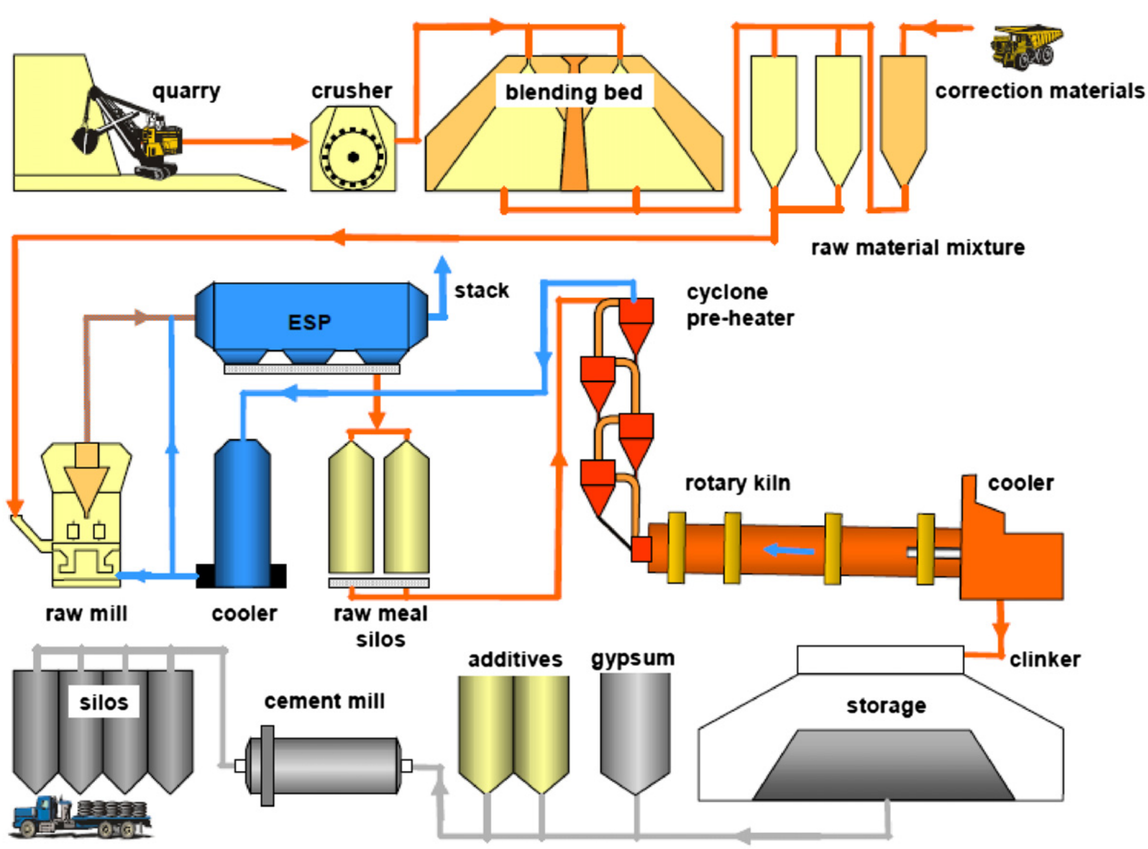

Fig. 1. Schematic representation of cement production.

than 2,000 PCDD/PCDF cement kiln measurements had been evaluated, representing most production technologies and waste feeding scenarios.

Cement rotary kiln co-processing of hazardous wastes and cement based solidification/stabilization could both immobilize heavy metals. In [11], the different retention mechanisms of the two technologies lead to different fixation effects of heavy metals.

In [12], 16 cement plants with new suspension preheater and pre-calciner (NSP) kiln were surveyed. Plant energy use was compared to both domestic (Chinese) and international best practice using the benchmarking and energy saving tool for cement (BEST-Cement).

Hashimoto et al. [13] were one effort to examine the present and potential performances of CO_2 emission reduction through industrial symbiosis by employing a case study approach and life cycle CO_2 analysis for alternative industrial symbiosis scenarios.

In [14] a systematic methodology was presented for the simultaneous optimal selection of raw materials, fossil fuels and alternative fuels in cement production.

The objective of [15] was to assess the environmental effectiveness of a strategic measure aimed at resource productivity enhancement, where the cement industry was identified as a relevant sector for this global issue, since the related production process enables the use of waste in partial substitution of raw materials and in substitution of traditional fuels.

The process of producing cement products from solid waste can increase the level of pollutants in the cement products. Yang et al. [16] presented acceptance limits for the availability of heavy metals in cement products which had been produced from solid wastes and explained how the limits had been calculated.

In [17], accelerated carbonation tests (10 vol% of CO_2) were performed on concrete specimens containing different amounts of blast-furnace slag (slag-to-binder ratios of 50%, 70% and 85%) after different curing times (1, 3, 6 or 18 months).

Liew et al. [18] aimed at investigating the possibility of calcined kaolin to produce cement powder that could be an alternative to Portland cement by applying geopolymerization process and the parameters involved in processing route defined were investigated.

A novel linear algebraic model was presented in [19], which isolates combustion stoichiometry invariants from fuel feed flow rates (decision variables), in order to investigate the use of alternative fuels may necessitate production volume reductions from the nominal value achieved by fossil fuels, leading to considerable profit reductions.

Also methods to estimate energy-ecologic efficiency have been studied, such as [20,32].

In [20] the evolution of the thermo power plant (TPP) Voitsberg of Austria from the past was presented and analysed, when there were no measures taken against pollution, to the present, when it was provided with desulphurization (Desulph) and Denox systems and installations, and it was globally evaluated from the point of view of its energy ecologic efficiency.

In [21] the results of the analysis of thermo power units with circulating fluidized bed boilers (CFBB) was presented where a global methodology was applied to estimate the energy-ecologic efficiency of these units.

In [22] a methodology was presented for global estimation of the energy-ecologic efficiency of thermo power plants resulting from the application of an analogy between the harmful flue gases impact (SO_2, NO_x) on the environment and the seismic activity of the earth's crust.

In [23] the evolution of the coal fired power plant/thermal power plant (CFP/TPP, denoted by CFP) in China from the past was analysed, when there were no measures taken against pollution, to the present, when the interest was aroused to provide depollution systems and installations.

In [24] the criteria of fuels characterization was discussed. For hydrocarbons, these criteria depend on the relation of the hydrogen (H) and carbon (C) contents of the respective hydrocarbons. To analyse a large range of fuels from the energy-ecologic point of view (coal, refinery residues etc.), it was concluded that the best criterion was the pollution indicator Πg.

In [25] the possibility of dual fuels (DFs) applications in existent thermo power plants (TPPs) was analysed in order to enable their pollutant emissions to conform to the ecological norms, which limit their values. In this analysis, all the primary fuels that are most commonly used in Romanian TPPs (coal, fuel oil) were included and as secondary fuels to form DF, we consider methane gas and hydrogen.

Cardu and Baica [26] had improved the computing relation for "carbon dioxide equivalent" by considering the toxic effect of the carbon monoxide (CO) emitted by thermo power plants (TPPs) together with other noxious gases (CO_2, SO_2, NO_x).

Cardu et al. [27] focused on the analysis of thermo power plants emissions with regard to a new indicator, SONOX (SO from SO_2 and NOX from NO_x), which was symbolized by S. Based on this method, analysis was accomplished for several Romanian thermo power plants fuelled by lignite.

Lora and Salomon [28] had intended to evaluate the environmental impacts of the atmospheric pollution resulting from the burning of fossil fuels; considering the emissions of CO_2, SO_x, NO_x and PM in an integral way, and they were compared to the international air quality standards that are in force using a parameter called ecological efficiency (ε).

Modelling of effects of fuel quality on the emissions of major pollutants (NO_x, SO_2, CO_2 and PM) and eight trace elements (As, Co, Cr, La, Mo, Ni, Sb and U) from a 300 MW boiler unit fired with Thai lignite was the main focus of [29]. The NO_x and SO_2 emission models were validated with the use of experimental data. Emission rates and specific emissions (per MWh) of the major pollutants and trace elements were quantified by including efficiencies of the flue gas desulphurization system and electrostatic precipitators in the computations.

In [30] a new criterion – SONOX – which can be used to analyse the thermo power plants (TPPs) operation impact on the environment through noxious gas emissions (sulphur and nitrogen oxides) in the atmosphere was introduced. Based on this criterion and applying the equivalence and the compensation principles, developed by the authors in some of their previous papers, some main Romanian TPPs were analysed and some recommendations are given in order to join the European Union norms regarding the respective emissions limits.

Coronado-Rodriguez et al. [31] had evaluated and quantified the environmental impact from the use of some renewable fuels and fossils fuels in internal combustion engines. The ecological efficiency concept depends on the environmental impact caused by CO_2, SO_2, NO_x and particulate material (PM) emissions.

Silveira et al. [32] aimed with an approach for cogeneration plants evaluation based on thermoeconomic functional diagram analysis. Also ecological efficiency was evaluated.

2. Process description

2.1. Manufacturing process of Portland cement

The cement industry is characterized by intensive use of energy, whether in the form of heat, used in rotary kilns for clinker production, whether in the form of electricity consumed throughout to move industrial process machinery, and to rotate kilns and mills. Most of the energy consumption for cement manufacturing, however, occurs in the production of clinker (rotary kiln), about 63% [33].

Table 1
Brazil: technical characteristics of the cement industry [5,6].

Parameter	Data
Process	Dry way, 98% of production
Specific consumption of thermal energy	3,260–3,770 kJ/kg of clinker (780–900 kcal/kg)
Specific consumption of electrical energy	80–150 kWh/ton cement, 70% into milling systems
Milling systems	75% of mills working in closed loops

Table 1 relates the main technological characteristics of cement industry in the country.

2.2. Co-processing: alternative fuels

In order to meet current production requirements, such as environmental and energetic restrictions are increasingly used alternative fuels derived from industrial waste. The cement industry has the potential of reusing waste from other industries as a substitute fuel or raw material. This activity is known as co-processing [6,34–35].

Co-processing is defined as an incineration carried out in rotary kilns for clinker production, properly licensed for this purpose, with the use of energetic inside and/or mineral fraction exploitation as raw material without generation of new waste [6].

The kilns were used for cement production, because the high temperatures reached inside, amounting to about 1,450 °C, combined with the highly oxidizing environment and the large residence time of material exposed to these conditions, represent an alternative recognized properly and are disseminated to thermal destruction of industrial wastes [6].

Beyond to eliminate the environmental liability posed by industrial waste, enables the replacement of traditional non-renewable fuels such as petroleum coke, fuel oil, and coal, through the reuse of energy waste. In turn, mineral compounds present in them are incorporated into the product mass, replacing part of the raw materials and saving natural resources [34,35].

All this must always meet the requirements of relevant environmental bodies and to preserve, above all, quality and characteristics of cement. Co-processing is performed and widely spread in Europe, USA and Japan since the 70s. In Brazil, the first practice started from the 90s, having been regulated nationally in 1999, by Resolution CONAMA 264 [6].

The use of some of these industrial wastes as secondary fuels in cement production has been a viable way for cement industries to reduce their costs of production, the consumption of fossil fuels, and contributes to the final disposal of such waste, as in the case of used tires, which are reused as fuel for burning the clinker formation [36,37].

2.3. Positive impact of co-processing

Among the major benefits of the co-processing are included [6]:

(a) reduction and greater control of emission levels of pollutants;
(b) replacement of conventional fuel up to 30%;
(c) reduction in energy consumption;
(d) increased investment in the environmental area;
(e) competitiveness gain; and
(f) improving the company image in the community.

3. Wastes usually co-processed

Some properties of industrial waste that will be used as alternative fuels and alternative raw material must be analysed, such as physical condition of the fuel (solid, liquid, gas), toxicity (heavy metals and organic compounds), composition and content of ash, amount of volatile, calorific value and moisture content. Knowledge of these properties is important because the chemical quality of the alternative fuel must comply with environmental protection laws, its calorific value should be stable enough to allow the control of feeding in the rotary kiln. The physical form must be easy to handle for transportation to a cement plant [38].

The composition of industrial waste is important, not only in emissions generated by these metals to the atmosphere, but also for their influence on the properties of cement. Most of the waste (80%) is used in furnaces as an alternative fuel due to the fact that its calorific value is greater than 7,100 kJ/kg (lower heating value) [39–41].

The wastes usually co-processed are [36,42]:

(a). used oil, including lubricant;
(b). soil contaminated with fatty oil, soil contaminated with oil (fuel or lubricant), oily waste (rags, wood chips, sawdust, vegetation impregnated with oil and water, air, paper towel with oil etc.), oily sludge, oil blurs, oil sand, grinding blurs, soluble oil, oil in emulsion, dirty oil, waste grease, used grease, blanket filter (oil filter) etc;
(c). waste clean-up:
- with solvent in paints manufacture;
- with water or caustic materials in paints manufacture;

(d). neutral blurs from re-refining used oils;
(e). solid waste compounds of non-toxic metal;
(f). slag molten of aluminium, iron, steel, and zinc;
(g). waste of non-metallic minerals;
(h). waste of paper, cardboard, polymerized plastic and textile materials;
(i). solutions exhausted from surface treatment bath with cyanide from electroplating operations;
(j). waste of acid washing of benzene, originating from distillation of coal tar coke;
(k). wastes from incineration or thermal treatment of contaminated soil;
(l). fund distillation residues from the production of nitrobenzene by nitration of benzene;
(m). paint blurs, painting waste, powder paint, paint booth filters, printing sludge, dyeing sludge, mix paints to solvents, water based paint waste, remnants of paints and solvents, multi-cyclone waste (soot);
(n). solvents: asphalt emulsion (in solvent), asphalt with reducing, paraffin solvent with paint, solvents, dirt solvents, solvents with water, blurs (in liquid) of perchloroethylene, mix resin with solvent, triethyleneglycol.

Fig. 2 shows useful potential wastes for co-processing in a cement plant.

4. Co-processing of tires

The accumulation of used tires is an environmental liability, estimated at one hundred million carcasses in Brazil. The technologies used to dispose the used tires are retreads, regeneration, energy recycling, pyrolysis, asphalt composition, and various forms of reuse. The improper disposal of used tires can turn them into sources of environmental and public health problems [43,44].

In 1999 the National Environment Council—CONAMA approved a resolution, with the force of law, the resolution no. 258 of August 26, 1999, to regulate the final destination of waste tires. The resolution established a timetable for the destruction of these tires since 2002 [6].

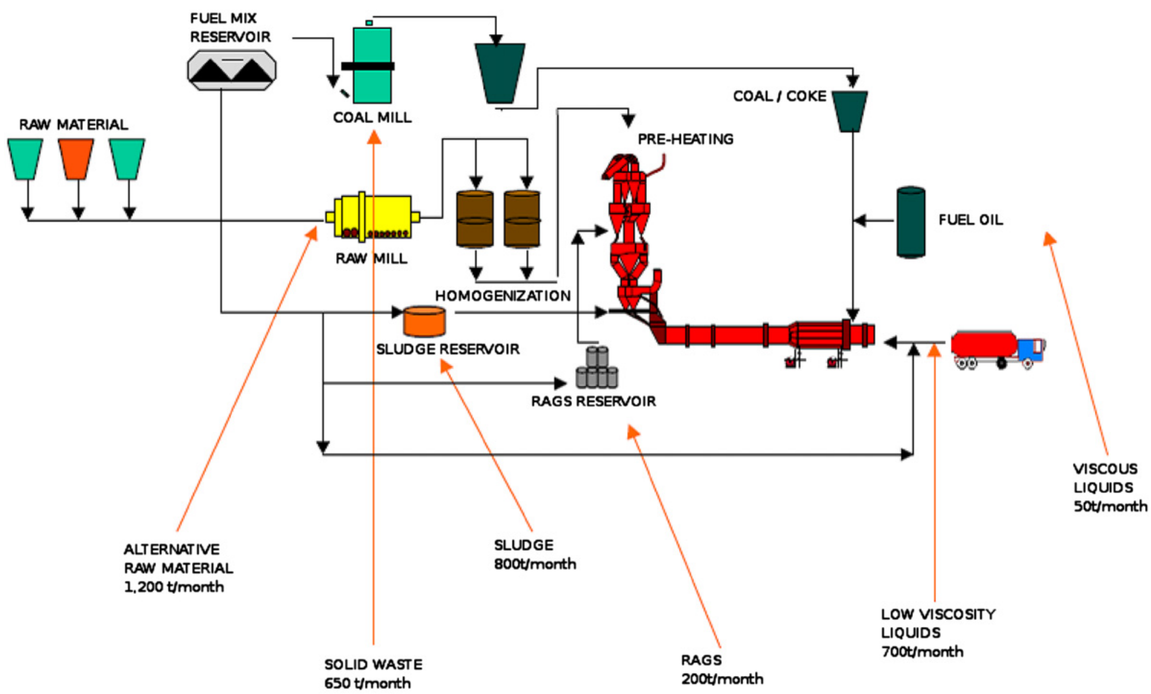

Fig. 2. Potential recycling materials in a cement facility.

Table 2
Evaluation of the savings generated by replacing 15% of fuel by waste.

Description	Unit	Value
Annual production of cement	ton	1,500,000
Total work days of kiln	days/year	330
Daily production of clinker	ton	4,545
Energy consumption/kg of clinker	kcal	800
Daily energy demand	10^9 kcal/day	3.6
Lower heating value of petroleum coke [48]	kcal/kg	8,200
Daily fuel amount	ton/day	443,459
Daily fuel savings with replacement of coke by waste (15%)	ton/day	70.29
Cost of petroleum coke [5]	US$/ton	61
Daily savings with fuel (coke)	US$/day	4,287.69
Annual savings with fuel	US$/year	1,414,938

The use of scrap tires as alternative fuel is considered, among the ways to recycle tires, as the most viable means for its disposal. Demand for the use of tires as a supplemental fuel in rotary cement kilns have been raised and widely discussed [43,44].

Worn tires, although a particular residual material, are excellent sources of energy, especially when used as secondary fuels. Tires can be completely destroyed in the rotary kiln due to the characteristics of these devices that combine extremely high temperatures with an oxidizing atmosphere and a residence time of material relatively long. The complete combustion prevents the formation of soot or odours [43].

Tires are composed of about 88% of carbon and oxygen, why have a very lower heating value about 32,100 kJ/kg, and come quickly burning. The high calorific value of the tires contribute to lower consumption of non-renewable fuels (coal and oil), thus saving natural resources [45].

But the use of tyre as a fuel is limited to a maximum of 30% for both domestic and international cement industry due to the presence of heavy metals in their composition, mainly zinc. This has the effect of lowering the initial resistance, but ensures higher final strength of the cement [46–47].

In Brazil 57% of scrap tires that are discarded each year were intended to cement kilns. It is noteworthy that in 2006 Brazil produced 54.5 million units of tires. One third of that is exported to over 85 countries and the rest run on domestic vehicles. It is possible to recover energy by burning old tires in cement kilns, whole or shredded—each tire contains the energy of 9.4 l of petroleum [44].

In Brazil, the use of tires as fuel promoted in the period from 1999 to 2004 the destruction of 150 t of tires, equivalent to 30 million used tires, saving 720 thousand tonnes of oil. The Petrobras facility in Sao Mateus do Sul, Parana, incorporates the extraction of bituminous shale, ground tires that ensure lower viscosity of the mineral and process optimization [44].

5. Evaluating the savings generated by co-processing

A direct calculation with production values relating to plant of Balsa Nova, Parana, provides a rough idea of what is potentially the co-processing to a factory to produce Portland cement. Taking as an example to calculate a 15% replacement of fuel (petroleum coke) for industrial waste will have the values shown in Table 2.

Moreover, following the same reasoning, 15% substitution of 3.63 billion kcal/day is equivalent to 545.45 million kcal/day. Using a waste of lower heating value of 3,000 kcal/kg would be

required 181.8 t of waste per day. Assuming that the factory charges a fee of 100.00 US$/t of incinerated waste, daily revenue would be US$ 18,180.00 and the annual US$ 5,999,400.00.

Thus, adding the fossil fuel economy and revenues from the burning of waste, involving these hypothetical values, the co-processing in a kiln reach the amount of US$ 7,414,337.70 per year. And it would have burned 59,994 t of waste over a year.

Whereas 70% of the value of investment in burn technology, providing a payback period up to five years, which still represent a total of US$ 2,224,301.30.

6. Ecological efficiency analysis

The ecological efficiency evaluates the pollutant amount of a system, considering gases emissions per kg of fuel used. This efficiency is ranged between 0 and 1, where an ecological efficiency equal to 0 means 100% of environmental impact, or high polluter, and efficiency equal to 1 means 0% of environmental impact, or non-polluter.

Cardu and Baica [49,50] had introduced the concept of carbon dioxide equivalent [$(CO_2)_e$], based on maximum concentration allowed for CO_2, which is 10,000 mg/m^3. The equivalent coefficients for some pollutants, in kg per kg of fuel (kg/kg$_{fuel}$), called global warming potential (GWP), are related according to Eq. (1) [32,51–53].

$$(CO_2)_e = CO_2 + 1.9\cdot(CO) + 25\cdot(CH_4) + 50\cdot(NO_x) + 80\cdot(SO_2) + 67\cdot(PM) \tag{1}$$

An indicator is proposed by [49] to quantify environmental impact and it is defined as the difference between carbon dioxide equivalent of fuel and its low heat value. This indicator is called pollution indicator represented by Π_g, Eq. (2).

$$\Pi_g = \frac{(CO_2)_e}{LHV} \tag{2}$$

where

$(CO_2)_e$—carbon dioxide equivalent (kg/kg$_{fuel}$);
LHV—low heat value of fuel (MJ/kg$_{fuel}$);
Π_g—pollution indicator (kg/MJ).

Relating carbon dioxide emitted by fuel combustion process with its low heat value, Cardu and Baica [49] make possible comparison between different fuels. However a fuel can have a high low heat value and to emit a wide amount of pollutants into atmosphere or has negligible, or null, emissions of noxious gases, but cannot have the energy required to obtain a good efficiency in an industrial process.

Based on assumption that the best fuel is one that has the lowest pollution indicator, [49] propose a more complex and dimensionless index that expresses the ecological component of noxious gases emitted into atmosphere from the combustion of a fuel compared to useful energy produced in thermal power plants. The indicator proposed is called ecological efficiency (ε), such as Eq. (3).

$$\varepsilon = \left[\frac{0.204 \times \eta_{system}}{\eta_{system} + \Pi_g} \times \ln(135 - \Pi_g)\right]^{0.5} \tag{3}$$

According to [54,55], Brazil has the lowest average annual emissions of greenhouse gases, around 659 kg CO_2/t, against world average around 800–880 kg CO_2/t.

The ecological analysis is done through comparison between ecological efficiency, pollution indicator and values for CO_2 equivalent from cement industry rate, before and after adoption of waste reuse. Table 3 shows LHV for fuels commonly used in cement facilities and mainly co-processing materials used in this industry.

Table 3
LHV values for fuels used in cement industry [46–48].

Fuels	LHV (MJ/kg)
Coal	30.800
Fuel oil 1A	40.794
Petroleum coke	34.309
Waste	7.100
Tires	32.100

Table 4
GWP values for the case study plant before co-processing [45].

	GWP (kg/kg$_{fuel}$)
CO_2	5.177
CO	0.0013
CH_4	0.00002
NO_x	0.009
SO_2	0.009
PM	14×10^{-6}

Table 5
GWP values for the case study plant with co-processing policy.

	GWP (kg/kg$_{fuel}$)
CO_2	8.024
CO	0.003
CH_4	0.00004
NO_x	0.021
SO_2	0.021
PM	20.5×10^{-6}

6.1. *Evaluation of ecological efficiency for cement plant before waste reuse*

For evaluation of cement plant without co-processing practice a production of 84,600,000 t/year and a fuel consumption of 5,003,000 toe/year, resulting in a global efficiency (η_{system}) as 16.91 is considered. Table 4 shows global warming potential values for the case study plant before waste reuse policy adoption.

Carbon dioxide equivalent for facility on study is obtained applying values from Table 4 to Eq. (1).

$$(CO_2)_e = 6.351\left[\frac{kg}{kg_{fuel}}\right]$$

Actually, the most common fuel in cement industry is petroleum coke, and then following evaluations are based on it.

$$\Pi_g = 0.185\left[\frac{MJ}{kg}\right]$$

$$\varepsilon = 0.98$$

In this scenario, ecological efficiency appoints to an excellent environmental policy from this facility. Where it supposes application of technologies such as gases purification and reuse of these gases in cogeneration, i.e., CH_4 as combustion fuel in engines or reuse of gases heat into heat recovery steam generator (HRSG) systems.

6.2. *Evaluation of ecological efficiency for cement plant after waste reuse*

For evaluation of actual cement plant is considered a production of 84,600,000 t/year and a fuel consumption of 3,415,562 toe/year, resulting a global efficiency (η_{system}) as 24.79. Table 5 shows

global warming potential values for the case study plant after waste reuse policy adoption.

Carbon dioxide equivalent for facility on study with co-processing policy is obtained applying values from Table 5 to Eq. (1).

$$(CO_2)_e = 10.762\left[\frac{kg}{kg_{fuel}}\right]$$

Such as the case without recycling, petroleum coke was considered as main fuel.

$$\Pi_g = 0.314\left[\frac{MJ}{kg}\right]$$

$$\varepsilon = 0.98$$

In this scenario, there is increase of all GWP values, but ecological efficiency is the same. This GWP increased because incorporation of tires incineration into process, in order to replace fossil fuel by materials recycling in kilns.

7. Conclusions

The waste co-processing is a source of double gain for the cement industry, thereby setting an appropriate convergence of different interests, putting the clinker kilns, from the perspective of the industrial sector as a unique solution for both parts, that is oriented in the axis "waste (generation)–thermal destruction (disposal) - co-processing of residual fuels (production of thermal energy)" and meets the expectations of cement industry in its continuous search for low cost energy and regular supply, and the interests of large generator of waste, which yearns for promoting your final and quick destination.

Moreover, it is imperative that state environmental agencies have the technical capacity to ensure that companies practise co-processing without endangering the health of workers and populations living near the plants.

For this problem is minimized, seems to be a necessary investment in staff and infrastructure to increase the institutional capacity of these agencies.

Ecological efficiency methodology provides a way to show that waste materials are a viable source of alternative fuel to kilns. Despite tires incineration, this policy maintains the same efficiency, because it policy associated to technologies of gases purification and reuse of these gases in cogeneration, i.e., CH_4 as combustion fuel in engines or reuse of gases heat into heat recovery steam generator (HRSG) systems.

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